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HYBRID RETAINING WALL SYSTEM

CROSS-REFERENCE TO RELATED APPLICATION

This application claims the benefit of U.S. Provisional Application No. 60/431,033, filed December 4, 2002, which is incorporated herein by reference.

FIELD

The present invention relates to embodiments of a hybrid retaining wall made from a combination of interlocking block assemblies and unitary blocks.

BACKGROUND

Conventional retaining walls are used to secure earth embankments against sliding and slumping. Retaining walls are made of various materials such as concrete, solid masonry, wood ties, bricks and blocks of stone and concrete. Typically, blocks are placed in rows, or courses, overlaying on top of each other to form a wall. Pins or rods typically are used to interconnect blocks of a lower course with vertically adjacent blocks in an overlying course. For taller walls, a horizontal tie-back sheet (commonly referred to as a geofabric or geogrid) may be located between adjacent layers of blocks, and extended rearwardly into an excavated area to be backfilled for retaining the wall against the outward force of the earth being retained. The prior art is replete with different examples of such retaining walls and blocks.

Another type of retaining wall system uses block assemblies having two or more interlocking subcomponents. Such a system is shown in U.S. Pat. No. 5,688,078 to Hammer. In this system, each block assembly includes a frontal or face block that is exposed in the front surface of the wall, a trunk block extending perpendicularly from the rear of the face block, and a tail block connected to the rear end of the trunk block. Additional trunk and tail blocks can be included in each block assembly to extend the assembly deeper into the slope for adding anchoring strength.

Despite the innovations of the prior art, a need exists for new, improved, and more versatile systems for constructing retaining walls, and especially such walls for retaining embankments in which variable conditions exist within the embankment, which conditions dictate different engineering considerations for different portions of the embankment.

SUMMARY

The present invention concerns embodiments of a retaining wall system that combines unitary block structures and block structures having multiple interlocking subcomponents. The retaining wall system is used to construct hybrid retaining walls having one or more courses constructed from the unitary block structures and one or more different courses constructed from the block structures of interlocking subcomponents. To ensure stability of the courses of unitary blocks, a tie-back sheet

can be positioned between one or more adjacent courses of such blocks and extended into fill material retained behind the wall.

The block structures of interlocking subcomponents comprise multiple block assemblies placed side-by-side in respective courses. Each block assembly includes at least two interlocking block subcomponents. In particular embodiments, each block assembly includes a front block, an anchor block in parallel relationship with the front block, and an elongated trunk block extending between and connected at opposite ends to the front block and the anchor block. The block components desirably are connected to each other using dovetail connections that resist separation of the block components, laterally and longitudinally (either front-to-back or side-to-side in the wall).

In one implementation, one or more lower courses of a retaining wall are constructed from block assemblies, each comprising interlocking block components, and one or more upper courses are constructed from unitary blocks. Since the block assemblies do not require tie-back sheets, the block assemblies generally require less excavation than the unitary blocks. Thus, constructing the lower courses of the wall from the block assemblies minimizes excavation at the base of the wall. The courses of unitary blocks are constructed in the upper portion of the wall where little or no excavation is required to install tie-back sheets.

In another implementation, one or more lower courses of a retaining wall are constructed from unitary blocks and one or more upper courses are constructed from block assemblies. This wall configuration is desirable where little or no excavation is

required, but there is limited space behind the upper portion of the wall to lay tie-back sheets. For example, there may be a utility conduit or other obstacle behind the upper portion of the wall. Since the block assemblies do not require tie-back sheets, the courses at or above the obstacle are constructed from the block assemblies.

The retaining wall system can also be used to construct walls in which both unitary blocks and block assemblies are used in the same courses.

The foregoing and other features and advantages of the invention will become more apparent from the following detailed description of several embodiments, which proceeds with reference to the accompanying figures.

BRIEF DECRIPTION OF THE DRAWINGS

FIG. 1 is a top plan view of a block assembly comprising three interlocking components, according to one embodiment, that can be used for constructing hybrid retaining walls.

FIG. 2 is a perspective view of a front block of the block assembly shown in FIG. 1.

FIG. 3 is a perspective view of a trunk block of the block assembly shown in FIG. 1.

FIG. 4 is a perspective view of an anchor block of the block assembly shown in FIG. 3.

FIG. 5 is a perspective view of a unitary block, according to one embodiment, that can be used for constructing hybrid retaining walls.

FIG. 6 is a perspective view of a portion of a retaining wall, according to one embodiment, having plural courses constructed from the block assemblies of FIG. 1 and plural courses constructed from the unitary blocks of FIG. 5.

FIG. 7 is a perspective view of a portion of a retaining wall showing courses constructed from the unitary blocks of FIG. 5 and a tie-back sheet positioned between the upper two courses of blocks.

FIG. 8 is an enlarged, perspective view of a block-connecting element, according to one embodiment, used for interconnecting vertically adjacent blocks.

FIG. 9 is a cross-sectional view of another embodiment of a hybrid retaining wall comprising six lower courses of block assemblies and six upper courses of unitary blocks, with tie-back sheets between some of the upper courses.

FIG. 10 is a cross-sectional view of another embodiment of a hybrid retaining wall comprising six lower courses of unitary blocks and six upper courses of block assemblies, with tie-back sheets between some of the upper courses.

DETAILED DESCRIPTION

According to one aspect, the present disclosure concerns a retaining wall system for constructing "hybrid" retaining walls. As used herein, a "hybrid" retaining wall is a retaining wall having one or more courses constructed from a plurality of block

assemblies of interlocking block components, and one or more different courses constructed from a plurality of unitary blocks positioned above or below the courses of block assemblies. A "hybrid" retaining wall can also include courses that include both unitary blocks and block assemblies. One embodiment of such a retaining wall system includes a plurality of I-shaped block assemblies 10 (FIG. 1) for constructing one or more courses of a wall and a plurality of unitary blocks 60 (FIG. 6) for constructing one or more different courses of the wall. Each of the block assemblies 10 comprise two or more interlocking block components, as further described below.

To increase the stability of courses constructed from blocks 60, tie-back sheets typically are disposed between one or more adjacent courses of such blocks and extended rearwardly into the backfill material retained behind the wall. Course of blocks 60 stabilized with such tie-back sheets typically can be backfilled with less expensive backfill materials than are used to backfill courses block assemblies 10. For example, silts or clays can be used to backfill most walls constructed from blocks 60, whereas higher quality backfill materials, such sands or gravels, may be required when constructing walls from block assemblies 10. Thus, it is generally more economical to use blocks 60 for constructing a wall where extensive backfilling is required to fill a void between a native embankment and the wall under construction. On the other hand, since block assemblies 10 do not require the use of tie-back sheets to stabilize a wall, courses that are made from block assemblies 10 generally require less excavation than courses that are made from unitary blocks 60. Thus, to facilitate wall construction and

to reduce material costs, it would be desirable to construct one or more lower courses of a wall from block assemblies 10, and then construct one or more upper courses from blocks 60 where minimal or no excavation of the native embankment is required.

FIG. 9, for example, illustrates a hybrid retaining wall 100, according to one embodiment, in which block assemblies 10 are used to form the lower six courses 102a, 102b, 102c, 102d, 102e, and 102f of the wall and unitary blocks 60 are used to form the upper six courses 102g, 102h, 102i, 102j, 102k, and 102l of the wall. A course 102m of capping blocks 106 can be constructed on top of the uppermost course 102l of blocks 60 to finish the wall. Of course, the number of courses of block assemblies 10 and the number of courses of blocks 60 can vary depending on the particular application.

In the illustrated embodiment, courses 102a-102f of block assemblies 10 extend from the base of the wall to approximately the height of the native embankment 104. Courses 102g-102l of blocks 60 are positioned above courses 102a-102f and form the portion of the wall above the height of the native embankment 104. Tie-back sheets 108 are positioned between courses 102g and 102h, courses 102i and 102j, and courses 102k and 102l, and extend rearwardly into the backfill material 110 retained behind the wall 100. The number of tie-back sheets 108 used in the wall can vary and primarily depends on the overall height and length (horizontal distance) of the wall. As illustrated in FIG. 9, the use of block assemblies 10 in courses 102a-102f minimizes excavation during construction of the wall 100 because it is not necessary to excavate the native embankment 104 for placement of tie-back sheets in these courses.

Aggregate 110 desirably is used to fill a volume of limited depth behind courses 102g-102l and to fill the voids between horizontally adjacent blocks 60 (not shown in FIG. 9) to facilitate water drainage to the base of the wall 100. Although not shown in FIG. 9, aggregate 110 also can be used to fill the voids defined between horizontally adjacent block assemblies 10. A perforated drainage conduit, or pipe, 114 can be used at the base of the wall to carry water away from the wall. Suitable backfill material 112 (e.g., soil) is used to fill the volume behind block assemblies 10 in courses 102a-102f and behind aggregate 110 in courses 102g-102l.

FIG. 10 illustrates another embodiment of a hybrid retaining wall, indicated generally at 200, constructed in front of a native embankment 210. Retaining wall 200 includes lower courses 202a, 202b, 202c, 202d, 202e, 202f constructed from blocks 60 and upper courses 202g, 202h, 202i, 202j, 202k, and 202l constructed from block assemblies 10. A course 202m of capping blocks 106 can be constructed on top of the uppermost course 202l of block assemblies 10 to finish the wall. Tie-back sheets 108 are used to stabilize courses 202a-202f of blocks 60.

In this embodiment, the upper courses 202g-202l are constructed from block assemblies 10, rather than blocks 60, because space behind these courses for placement of tie-back sheets is limited by a utility conduit 204 (e.g., a sewer or water pipe). In addition, by constructing the upper courses from block assemblies 10, access to the utility conduit 204 by maintenance personnel is not restricted by any tie-back sheets overlaying the utility conduit.

As shown in FIG. 10, aggregate 208 can be used to fill a volume of limited depth behind courses 202a-202f, and to fill the voids between horizontally adjacent blocks 60 and between horizontally adjacent block assemblies 10. A perforated drainage conduit, or pipe, 114 can be used at the base of the wall to carry water away from the wall. Suitable backfill material 210 (e.g., soil) is used to fill the volume behind block assemblies 10 in courses 202g-2021 and behind aggregate 208 in courses 202a-202f.

In some applications, the conditions along the length of an embankment can vary. For example, existing site conditions may not permit excavating certain portions of an embankment because of natural obstacles in the embankment (e.g., trees) or because there are buildings or other structures above or near the embankment that would be jeopardized by excavation. Where such varying conditions exist along the length of an embankment, one or more courses of retaining wall can be constructed from both block assemblies 10 and block assemblies 10. For example, portions of courses 102g-1021 in FIG 9 can be constructed from block assemblies 10 if an obstacle behind the wall (e.g., a tree) would prevent the use of tie-back sheets.

Referring now to FIG. 1, the construction of the block assemblies 10 will be described. Each block assembly in the illustrated configuration typically includes at least three interlocked, vertically oriented planar blocks. Additional blocks can be added to a assembly to increase the depth of the assembly, as further described below. As shown in FIG. 1, a veneer or face block 12 (also referred to herein as a front block)

has a face or front surface 14 that is exposed in the front surface of a wall. The front surface 14 desirably has textured or broken face resembling natural stone. An elongated trunk block 16 is attached to the rear of the face block 12 at a vertical medial junction thereon. The trunk block 16 extends perpendicularly from the face block 12 in the rearward direction. A tail block 18 (also referred to herein as an anchor block) is attached to the rearward end of the trunk block 16 so that it is parallel to the face block 12, with the trunk block being attached to the tail block at a vertical medial junction.

The front face 14 of the face block 12 can have any of various configurations. In the illustrated embodiment, for example, the front face 14 has a two-faceted front face configuration having first and second angled surfaces 14a and 14b. In other embodiments, the front face can have a convex curved surface, a single-faceted configuration, or a three-faceted configuration comprising a center facet and two angled side surfaces extending rearwardly from respective sides of the center facet.

When constructing a wall, the face block 12, trunk block 16, and tail block 18 are assembled to provide an interconnected I-shaped assembly 10, as depicted in FIG. 1. In the interconnected state, the components of the assembly 10 may not be disconnected or separated in any lateral direction (i.e., side-to-side or front-to-back in a wall) without breakage. The block components in the illustrated embodiment are not merely held in place by frictional forces and the presence of adjacent unconnected blocks. Each block component is securely mechanically engaged to at least one other adjacent block component of the same block assembly 10.

In particular embodiments, the face block 12, trunk block 16, and tail block 18 are interconnected by dovetail joints so that they may be separated only by vertically sliding one block component with respect to an attached block component. A dovetail joint may be formed in any of a wide variety of geometries as long as the block components are connected against lateral separation. Dovetail joints generally have a male key or tongue 20 that mates with a female slot or groove 22. Typically, the tongue is wider at some position toward its free end than at another position closer to its root. The female groove 22 is configured to closely conform to the male shape of a tongue 20. In the illustrated embodiment, the face block 12 and tail block 18 define the vertical grooves 22, which are generally trapezoidal, with the face being wider than the aperture at the surface of each block. Compatible male tongues 20 are integrally formed on the ends of the trunk block 16, with the free end being wider than the root.

Although less desirable, the face block and the trunk block can be formed as a single unit that is interconnected with a separable tail block. Thus, in this configuration, the block assembly has only two interconnected block components. In a similar manner, the trunk block and the tail block can be formed as a single unit that is interconnected with a separable face block.

FIG. 2 shows the face block 12 with the groove 22 only partially bisecting the block. The groove 22 does not entirely pass through the block, but terminates at a sloped end surface 24 that faces generally upward and rearwardly of the block. Thus, the lower portion of the face block 12 is solid and unbroken by the groove 22, thereby

increasing the strength of the block and decreasing the risk of breakage at the groove 22.

FIG. 3 shows the trunk block 16 with a male tongue 20 at each end of the block. Each tongue 20 desirably has a sloped lower end 30 corresponding to the end surface 24 of a corresponding female groove 22 in the face block 12 or the tail block 18. Desirably, the tongue 20 does not extend the length of the block, but stops at the sloped end 30 to permit the trunk block 16 and the face block 12 to be interconnected with provide flush top and bottom surfaces. In other embodiments, the tongues 20 and grooves 22 can extend the entire height of the respective block component.

FIG. 4 is a perspective view of the tail block 18. The illustrated tail block 18 desirably is formed with a female groove 22 centrally defined on the front and rear faces according to the configuration of the groove 22 formed in the face block 12. The grooves 22 are oriented back-to-back and spaced apart by a solid web 32 of block material to provide adequate strength. The tail block 18 also may be formed with a male tongue 20 on each end, as depicted in FIG. 4. This allows the tail block 18 to be optionally used as a trunk block to provide a block assembly having an overall depth that is shorter than the depth of the block assembly 10 shown in FIG. 1.

The tongues 20 and grooves 22 are all similarly tapered along their vertical lengths so that each dovetail joint is secured against excess motion and slippage by the respective tongue 20 being wedged into the respective groove 22. In a maximum material condition (i.e., when the spaces between adjacent block assemblies are

completely filled with a fill material (e.g., gravel)), the trunk block 16 may ride slightly above a flush alignment with the adjoining blocks. In a minimum material condition (i.e., when the spaces between adjacent block assemblies are less than completely filled), the end surface 24 of a groove 22 and the sloped end 30 of a corresponding tongue 50 will abut to prevent the trunk block from being excessively below an aligned level.

As shown in FIGS. 1 and 2, the face block 12 desirably includes alignment channels 26 defining oblong bores elongated in the direction of the width of the block and passing vertically through the entire block. In addition, the face block 12 may be formed with pockets or recesses 28 elongated in the direction of the depth of the block intersecting intersect respective alignment channels 26. As shown, the rear portions of the pockets 28 desirably extend to a limited depth toward the bottom of the block.

The pockets 28 are configured to receive block-connecting elements 50 to interconnect the face block 12 with two face blocks of an overlaying course. As best shown in FIG. 8, each block-connecting element 50 in the illustrated embodiment includes a lower portion comprising a rectangular plug 52 and an upper portion comprising a pin or rod 54. In use, the plug 52 of a block-connecting element is inserted into a pocket 28 and the pin 54 is inserted into an alignment channel 26 of an overlaying face block. As shown, the pin 54 is offset toward one end of the plug 52 to accommodate vertical walls and setback walls. If a vertical wall is desired, the block-connecting elements 50 are inserted into respective pockets 28 in a “forward” direction

(as depicted by block-connecting element 50 in FIG. 2) so that the pins 54 are closer to the front surface of the face block 12. If a setback wall is desired, the block-connecting elements are inserted into respective pockets 28 in a "reversed" direction (as depicted by block-connecting element 50' in FIG. 2) so that the pins are closer to the rear surface of the face block 12.

Since the alignment channels 26 are elongated in the direction of the block width, the channels provide lateral accommodation for block offset in curved walls with setback. Desirably, the alignment channels 26 are generally centered on the "quarter points" of the upper surface of the face block 12; that is, each channel 26 is centered at a location that is spaced from an adjacent side 34 of the block a distance equal to one-quarter the total block width (i.e., the distance between sides 34). This facilitates wall construction when building curved walls.

In alternative embodiments, the alignment channels 26 may be used to retain vertical reinforcing bars passing vertically through several layers of a wall, in lieu of block-connecting elements 50.

FIG. 6 illustrates the placement of block assemblies 10 in a retaining wall, which is indicated generally at 300. The wall 300 has courses 302a, 302b, and 302c constructed from block assemblies 10 and courses 302d and 302e constructed from unitary blocks 60. Each course 302a-302e is generally horizontal and extends in a rearward direction A into an embankment (not shown in FIG. 6).

Each course 302a-302c comprises a row of block assemblies 10 placed side-by-side with respect to each other so that their trunk blocks 16 are generally parallel and the face blocks 12 are positioned side-by-side in a continuous line. Thus, a pair of adjacent assemblies defines a generally rectangular chamber 38 suitable for filling with a suitable backfill material (desirably aggregate) to provide stability and drainage. Each chamber 38 is defined at its sides by the trunk blocks 16 of the respective assemblies 10 and at its front and rear by the face blocks 12 and tail blocks 16 of the respective assemblies.

Each course may be set back by a small distance with respect to an adjacent lower course to create a slightly sloping wall face, although in other implementations the successive courses can be vertically aligned to form a vertical wall without a setback. Nonetheless, each face block 12 rests on two face blocks 12 of a lower layer and each tail block 18 rests on two tail blocks of a lower layer, with each trunk block 16 being suspended above a chamber 38 in the layer below.

For additional stability, block-connecting elements 50 can be used to interconnect vertically adjacent face blocks 12, in the manner described above. Since each face block 12 is supported by two face blocks 12 of a lower layer, one alignment channel 26 of a face block receives a pin 54 of a block-connecting element 50 that is supported in a pocket 28 of one of the supporting face blocks in the layer below and the other alignment channel 26 receives a pin 54 of a block-connecting element 50 that is supported in a pocket 28 of the other supporting face block in the layer below.

As best shown in FIG. 1, the face block 12 has a width W_1 defined between the side surfaces 34 and the tail block 18 has a width W_2 defined between the tongues 20 formed on its opposite ends. The width W_1 desirably is greater than the width W_2 so that convex curved walls may be formed by bringing together adjacent tail blocks 18 in a course closer than a parallel spacing would ordinarily dictate. To form a concave wall, the tail blocks 18 are spaced apart wider than ordinarily dictated but are not spaced apart so far that each tail block 18 does not rest on the ends of the spaced apart tail blocks of a lower layer. If a more sharply concave wall is desired, separate tail blocks may be positioned between adjacent tail blocks of the block assemblies 10 to support any unsupported tail blocks in an overlaying course.

As shown in FIG. 1, each block assembly 10 has a depth D defined between the front surface 14 of the front block 12 and the rear surface of the tail block 18. For additional anchoring stability in a wall, particularly in the lower layers of walls having several layers, the depths of the assemblies 10 may be extended in the rearward direction by attaching one or more extension assemblies 40 (FIG. 6). As shown in FIG. 6, each extension assembly 40 includes a tail block 18' attached perpendicularly to a trunk block 16' in a T-shaped arrangement as in a standard assembly 10. In each extension assembly 40, the trunk block 16' attaches to and extends perpendicularly from the center of the tail block 18 of the standard assembly 10.

Referring now to FIG. 5, each unitary block 60 in the illustrated embodiment includes a front portion 62, a rear portion 64, and a neck portion 66 extending between

the front portion 62 and the rear portion 64. The front portion 62 has a front surface 68 that is exposed in the front surface of a wall (such as shown in FIGS. 6 and 7). The front surface 68 desirably has a broken face to resemble natural stone. The block 60 desirably has a core 70 extending through neck portion 66 so as to define two wall portions 72, 74 extending between the rear surface of the front portion 62 and the front surface of the rear portion 64.

The upper surface 76 of the block 60 may be formed with alignment channels 78 and pockets, or recesses, 80 having a configuration that is similar to the alignment channels 26 and pockets 28 of the face block 12 (FIGS. 1 and 2). The alignment channels 78 desirably are generally centered on the "quarter points" of the upper surface of the front portion 62. The pockets 80 are dimensioned to receive plugs 52 of respective block-connecting elements 50. The block-connecting elements 50 can be inserted into the pockets 80 in a forward position for constructing a vertical wall or in a reversed position for constructing a setback wall, in the manner described above.

The front surface 68 can have any of various configurations. For example, in the embodiment shown in FIG. 5, the front surface 68 has a three-faceted configuration comprising a center facet 68a and two angled side facets 68b and 68c extending rearwardly from respective ends of the center facet 68a. In alternative embodiments, the block 60 can have a convex curved front face, a single-faceted front face, or a two-faceted front face (as depicted in FIG. 6).

FIG. 6 illustrates the positioning of blocks 60 in a retaining wall. As shown in FIG. 6, blocks 60 are placed side-by-side in abutting relationship with each other to form a continuous line of blocks in courses 302d and 302e. Chambers 82 for receiving a fill material are defined between horizontally adjacent blocks in each course 302d, 302e. The front portion 62 of each block 60 rests on the front portions 62 of two blocks 60 of a lower layer and the rear portion 64 of each block rests on the rear portions 64 of two blocks of a lower layer.

The front portion 62 of block 60 has a width defined between the opposite ends of the front face 68. The width of front portion 62 desirably is equal to the width W_1 of the face block 12 of the block assembly 10 (FIG. 1). Also, the height of block 60 desirably is equal to the height of block assembly 10. In this manner, the overall appearance of the face of a hybrid retaining wall having courses of block assemblies 10 and blocks 60 is consistent throughout the entire wall, as shown in FIG. 6.

Because the widths of blocks 60 are equal to the widths of face blocks 12, the channels 78 of a block 60 can be positioned to receive the pins 54 from block-connecting elements 50 that are supported in two face blocks 12 in a lower layer. For example, in the retaining wall 300 of FIG. 6, each block 60 of course 302d is positioned to receive the pins 54 of block-connecting elements supported in two face blocks 12 in course 302c. Alternatively, if courses of block assemblies 10 are constructed on top of courses of blocks 60 (as depicted in FIG. 10), a face block 12 can be interconnected to two blocks 60 in an adjacent lower course with block-connecting elements 50. In

addition, this block-connection system further allows a course of blocks 60 to be vertically aligned with a course of block assemblies 10 or positioned in a set-back relationship with a course of block assemblies 10.

As best shown in FIG. 5, the front portions 62 of blocks 60 are wider than the rear portions 64 so that convex curved walls can be formed by bringing together adjacent rear portions 64 in a course.

FIG. 7 illustrates the placement of a tie-back sheet 106 used to stabilize courses of blocks 60. In the embodiment shown in FIG. 7, the front edge of the tie-back sheet 108 is positioned behind block-connecting elements 50 and extends rearwardly into the fill material (not shown in FIG. 7) retained behind the wall, as previously described.

The present invention has been shown in the described embodiments for illustrative purposes only. The present invention may be subject to many modifications and changes without departing from the spirit or essential characteristics thereof. I therefore claim as my invention all such modifications as come within the spirit and scope of the following claims.